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MCC

Materials Characterization Center Program Plan

March 1980

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
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MATERIALS CHARACTERIZATION CENTER PROGRAM PLAN

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TABLES

GLOSSARY

ANSI	American National Standards Institute
ANS	American Nuclear Society
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
API	American Petroleum Institute
AWS	American Welding Society
BWIP	Basalt Waste Isolation Program
DOE	Department of Energy
HLW	high-level waste
IRG	Interagency Review Group
IMSL	Independent Measurement and Standards Laboratory
LLW	low-level waste
MCC	Materials Characterization Center
MCO	Materials Characterization Organization
MRB	Materials Review Board
NWVP	Nuclear Waste Vitrification Project
ORNL	Oak Ridge National Laboratory
ONWI	Office of Nuclear Waste Isolation
PNL	Pacific Northwest Laboratory
STEM	Scanning Transmission Electron Microscope
SRL	Savannah River Laboratory
SRP	Savannah River Plant
TRU	transuranic
TTC	Transportation Technology Center
UNI	UNC Nuclear Industries
WIPP	Waste Isolation Pilot Plant
WRIT	Waste Rock Interaction Technology Program
WSEP	Waste Solidification Engineering Prototypes

MATERIALS CHARACTERIZATION CENTER
PROGRAM PLAN

1.0 INTRODUCTION

The United States Department of Energy is supporting numerous programs at many laboratories to develop components of the nuclear waste containment system. Because of the need for a single focal point to provide a nuclear waste materials data base and supporting documentation, the Materials Characterization Center (MCC) has been established at Pacific Northwest Laboratory as part of the Materials Characterization Organization (MCO). The MCO is administratively designed to provide an authoritative, referenceable basis for establishing nuclear waste material properties and test methods. This organization will allow different materials to be compared more objectively and thus to help ensure the precision, reliability, and applicability of materials data involved in storage, transportation, repository design, and licensing activities, and to provide a means of quality assurance for the production of these materials.

The role of the MCC is to provide a data base that will include information on the components of the waste emplacement package--the spent fuel or processed waste form and the engineered barriers--and their interaction with each other and as affected by the environment. The MCC will plan materials testing, develop and document procedures, collect and analyze existing materials data, and conduct tests as necessary. After test methods and data have been approved by the Materials Review Board (MRB), which is also part of the MCO, the MCC will publish these approved methods and data in a Nuclear Waste Materials Handbook (hereafter referred to as the Materials Handbook). Approved procedures will be applied to candidate waste emplacement package materials to ensure a consistent basis for comparison. Validated data from these procedures will characterize waste materials for their radiological, chemical, physical, and metallurgical properties.

The MCC will coordinate its functions with DOE, DOE contractors, and other technical groups to avoid duplication of effort and to ensure completeness of the materials testing program. It will define its test procedures using acceptance criteria and waste repository requirements defined by other appropriate programs. The MCC will function as a clearinghouse of procedures and data generated from outside the MCC and will review, test, and submit them to the MRB.

This document begins with some background information on nuclear wastes and the need for standardized test methods and data, program management plans, and discussions of waste form materials charcterization, engineered barrier characterization, data dissemination, and systems testing. Appendix A presents the charter of the MCC and the MCO is described in Appendix B. The MRB charter is given in Appendix C to help show its relationship with the MCC. This program plan and the priorities of the MCC will be updated in September 1980 and annually thereafter to reflect new developments, criteria, and regulations that affect the MCC objectives.

2.0 BACKGROUND INFORMATION

Nuclear fission reactors have been a vital component of our military defense effort since World War II. In the last 20 yr, they have also become an increasingly important power source for our electric utilities. The transuranic and fission product waste by-products from these reactor operations have been placed in near-surface storage; however, methods are now being developed for permanent disposal of these wastes. The nuclear wastes destined for geologic disposal, the waste packages themselves, waste packaging criteria, and materials property data requirements will be discussed briefly in this section.

2.1 NUCLEAR WASTES DESTINED FOR GEOLOGIC DISPOSAL

The major categories of nuclear wastes and the approximate volume now in existence are shown in Table 2.1. High-level waste (HLW) is generated from the first stage of spent fuel reprocessing. It contains over 99% of the nonvolatile fission products plus a small quantity of uranium and transuranics due to "waste losses" from the reprocessing operation. (Two reprocessing plants producing defense wastes are currently operating in the U.S.) The majority of the HLW is an alkaline waste (i.e., the liquid acid waste from the separation process has been made alkaline with excess sodium hydroxide) and consists of a

TABLE 2.1. Quantities of Existing Wastes

Waste Type	Volume, m^3	
	Defense	Commercial
HLW	2.8×10^5 (a)	2.3×10^3 (a)
TRU	0.42×10^6	0.15×10^6
LLW	1.34×10^6	0.51×10^6
Spent Fuel	---	4,400 tons as of October 1978

(a) Savannah River Laboratory. 1979. Long-Term High-Level Waste Technology Program Strategy Document. DOE/SR-WM-79-3.

mixture of insoluble sludge, water soluble salt, and residual salt solution. HLW must be treated to transform it to chemically inert solid before disposal.

Transuranic (TRU) wastes are non-HLW wastes that contain more than 10 nanocuries of transuranic radioactivity per gram[a] and are also generated at reprocessing and defense plants. The liquid portion of TRU wastes must be sorbed on a carrier material, or otherwise immobilized, before disposal. As with HLW, the preferred disposal method for TRU wastes is burial in a deep geologic repository.

Some short-lived, low-level radioactive wastes from nuclear reactors, hospitals, and research laboratories are being disposed of in shallow burial grounds. These waste materials may be considered later by the MCC but will not be emphasized at this time.

Spent fuel discharged from commercial power reactors is an important category of nuclear material that is a candidate for geologic disposal.

2.2 WASTE PACKAGES

The waste packages that will be placed in deep geologic repositories will consist of a waste form and a series of engineered containment barriers. These barriers may include a canister, possibly overpack, hole sleeve and backfill material. The specially chosen geologic formation in which the repository is located and its overburden are additional barriers between the waste and biosphere.

2.2.1 Waste Form

The waste form, which includes spent fuel and reprocessed waste, is the solid material that actually contains the radioactive waste. Its function is to stabilize the waste in a small volume for safe handling, transportation, and disposal. It should provide low dispersibility for the waste radionuclides during handling and transportation and over the long-term in the geologic repository.

(a) This definition is currently under review and may be modified.

A large number of candidate processed waste forms exists. Glass is the most developed waste form for HLW. Others include crystalline ceramics (some of which are tailored to resemble naturally occurring stable minerals), calcines, cements and grouts, and composite forms, such as cermets, coated particles, and glass beads or other particles embedded in a metal matrix.

2.2.2 Canister, Overpack, and Hole Sleeve

The canister is the primary container in which the waste form is sealed; it must be compatible with the waste form and processing operations to which it is subjected. Candidates for canister materials include cast iron, mild steel, stainless steels, and various high chromium and nickel alloys.

The canister may be placed in a second container or overpack. The overpack can be added after processing and can be designed for special functions, such as assuring that the waste is retrievable from the repository for a given period of time. The same materials used for canisters may also be used for overpacks. However, since overpacks do not have to be in place during the waste processing operations, material selection is more flexible; materials such as titanium and zirconium alloys, graphite, oxide ceramics, cement, and polymers are being considered.

A hole sleeve or liner may be used to simplify installation of the backfill (i.e., nonradioactive environment) and also to enhance retrievability of the waste canister. Low alloy steels have been generally considered for this application; however, materials such as concretes may also be evaluated along with other overpack candidates.

2.2.3 Backfill Material

The canisters will be placed in holes in the floor or walls of repository tunnels. The waste package holes and tunnels will eventually be backfilled. The backfill material provides heat transfer and structural support, it may simply consist of crushed material removed during mining of the repository. But the opportunity is also provided for installing an additional engineered barrier by using materials whose properties provide additional ion exchange capacity, modify the pH or Eh, or impede water flow. Special backfill materials being considered include clays, zeolites, chemical grouts, and asphaltic materials.

2.2.4 Borehole Materials

Shafts and boreholes into the repository must eventually be filled and sealed to prevent human intrusion or water flow into the repository. Materials being considered for backfills are also potential candidates for borehole materials.

2.3 WASTE PACKAGING CRITERIA

Criteria that apply to engineered containment barriers are given in 10 CFR 50, Appendix F (solidified waste form),[a] which dates from 1971, and a proposed 10 CFR 60 (waste package),[a] which was circulated for comment in late 1979. The criteria for the waste form specify that liquid HLW be converted to a dry solid that is "chemically, thermally, and radiolytically stable" and placed in a sealed container prior to transfer to a Federal repository in a shipping cask that meets the requirements of 10 CFR 71.[a]

The proposed performance objectives for the waste package after it is emplaced in the geologic repository are 1) "that it will provide reasonable assurance of containment of the radionuclides at least for the first 1000 years and additional containment for as long as reasonably achievable thereafter," and 2) that "after the first 1000 years the waste package should also retard the radioactivity and limit its release rate to as low as reasonably achievable but to at most a release rate of one part in 10^5/yr." These proposed performance objectives may be modified with time, but in their present form they provide guidance in determining the materials requirements for the multiple barriers of the waste package.

Repository requirements and criteria are being identified by the Office of Nuclear Waste Isolation (ONWI) and others. As these are identified,

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(a) Code of Federal Regulations. Title 10, Part 50, proposed Part 60, and Part 71.

applicable elements will be incorporated into test development and data generation plans and activities. The requirement and criteria are important to the MCC to aid in defining the most applicable tests and in defining those properties for which standard methods are needed. It is anticipated that the MRB will be judging tests methods on their applicability to existing criteria and requirements.

2.4 MATERIALS PROPERTY DATA REQUIREMENTS

The function of the MCC is to provide standardized property data on waste materials to be used in

- the design of facilities and systems for waste treatment, handling, transportation, storage, and disposal
- decisions on the selection of materials for further research and development
- analytical models for safety analyses and licensing.

Typical information which needs to be provided to the MCC include storage temperatures, pressures, groundwater flow rates and compositions, anticipated radiation levels, and seismic shock characteristics. This information is needed for both normal and accident conditions. Definition of approximate performance requirements of the materials would ensure that MCC methods are sensitive to the data in the desired ranges.

The properties of each component of the waste package must be defined separately but each component must be considered a part of the multibarrier system. Interactions between the components of the system must be considered, particularly as they may affect the environments of the individual barriers. For instance, the radiation and thermal fields from the waste form affect the property measurements made on canister, overpack, and backfill materials.

Priority will be given to properties used to define the potential for airborne or waterborne dispersibility of radionuclides from the waste form. While the waste is on the surface, the potential for dispersion occurs only as the result of extremely severe accidents during handling, interim storage, or transportation. Both the air and water pathways must be considered. After the waste is emplaced in the repository, only the water pathway must be considered. Since it is accepted that water may contact the waste form at some time in the repository (but only after perhaps a thousand years unless there is an accident), the leaching characteristics of the waste form are important.

The waste materials properties data will be used in accident analyses. Selection of the potential accident parameters that will determine which data are needed will be an important part of standard test definition. Details of the program plan for standard test development and standard data acquisition are given in Sections 4, 5, and 6.

3.0 PROGRAM ORGANIZATION AND MANAGEMENT

The MCC is part of Programs at Pacific Northwest Laboratory (PNL) in Richland, Washington and is organizationally independent of other PNL nuclear waste management programs. The MCC has been organized into the five tasks shown in Figure 3.1. The program administration and planning task is discussed in this section; the other tasks are discussed in subsequent sections.

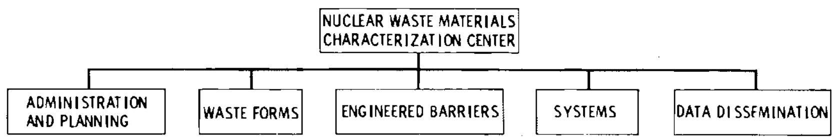

FIGURE 3.1. The Nuclear Waste Materials Characterization Center Organizational Structure

3.1 PROGRAM ADMINISTRATION AND PLANNING TASK

The responsibility for managing all functions of the MCC resides in this task. The functions of the task are

- providing administrative and technical management
- interfacing, communication, and coordination with other waste management programs, lead sites, and appropriate operations offices
- establishing priorities for MCC activities
- developing costs, schedules, and budgets
- implementing report and review requirements
- developing and updating program plans.

The MCC management office is comprised of the Program Manager, Associate Program manager, and a secretary. Technical and support staff are drawn as needed from the research departments in PNL and by subcontrcts external to PNL.

3.2 PROGRAM INTERFACES

The MCC must maintain interfaces with many organizations and programs that are developing, characterizing, or using nuclear waste materials. These interfaces have at least one of five potential relationships to the MCC. These include: 1) responsibility for direction, funding, and performance of the MCC, 2) programs and organizations from which the MCC needs input, 3) programs for which coordination of activities is desired to avoid duplication and to enable exchange of information, 4) subcontracts which directly support the MCC, and 5) other indirect support programs.

Those responsible for the overall direction, funding, and performance of the MCC are principally the Materials Characterization Organization (MCO) (Appendix B) and the Lead Waste Management Offices, and sites. The general activities of the MCC will be agreed to with these organizations on an annual basis with more frequent review and updates. As part of the MCO, the MRB will have a review responsibility on MCC activities. The Independent Measurements and Standards Laboratory (IMSL) is expected to provide technical review of the MCC when requested by the MRB or MSC.

The MCC needs the following input to its program:

- criteria provided by regulatory groups to guide the waste management system. These criteria will influence the test methods which need to be developed and the specific parameters associated with them.
- definition by repository developers of conditions that will exist in repositories and selection of materials and identification of data that are needed on these materials.
- identification by lead waste management sites of design and materials selection with the associated data needs
- provision of materials to be tested in a unified program by waste form developers.

The MCC will coordinate its test development and data generation with programs that are developing and testing waste materials. The MCC will obtain peer review of its methods and data from these programs and from universities.

Workshops will be one mechanism to establish and use these essential interfaces which will constitute a major source of technical information.

Subcontracts will be issued by the MCC to provide technical support. These subcontracts will be primarily with universities and DOE laboratories. Consultants will also be utilized where appropriate.

The characterization of materials and development of test methods will result in the identification of basic research needs. The MCC will not fund these needs but will provide recommendations for needed research to Basic Energy Sciences and others as appropriate. As the MCC program develops and commercial-scale operations become more clearly identified, then interfaces with industry will become more meaningful.

3.3 ACTIVITIES AND SCHEDULE

The schedule of activities of the MCC depends both on the order of activities, which is discussed in Section 3.3.1, and on the priorities given to various wastes, which are discussed in Section 3.3.2.

3.3.1 Activity Flowchart and Schedule

The initial activities of the MCC are directed at providing waste form characterization data for the Savannah River Plant (SRP) waste form selection in FY 1982[(a)] and the TRU Program.

The longer term activities of the MCC will be directed at 1) providing test methods and data that can be used to relate materials properties to repository criteria for design, licensing, and operations, and/or 2) routine process monitoring of production materials.

Activity Flowchart

Figure 3.2 shows inputs needed by the MCC, its activities and expected outputs, and their relationships to each other and MRB activities. The three

(a) Savannah River Laboratory. 1979. Long-Term High-Level Waste Technology Program - Strategy Document. DOE/SR-WM-79-3.

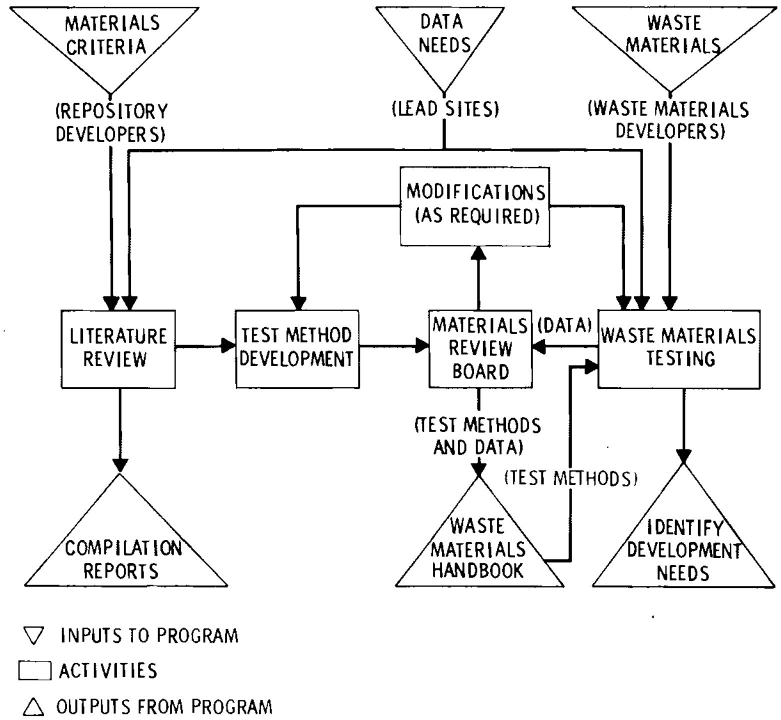

FIGURE 3.2. The MCC Activity Flowchart

inputs required for the program are 1) the definition of waste materials criteria by regulatory agencies and the identification of expected repository conditions by the repository developers, 2) identification of materials data needs by lead sites and others, and 3) waste materials for testing that are to be provided by waste-form developers.

The initial activity will review the literature to identify test methods, obtain background information, and to provide data for compilation reports (Section 7.1), which will be the first output of the program. Reviews of the literature, selection and development of appropriate test methods, and review of the test methods by the MRB will occur prior to comprehensive testing of materials. Should the test methods or materials data not be adequate, they will be returned to the MCC for modifications.

Once test methods are in place, the data needs can be met directly. For the FY-1982 SRP decision, candidate waste form materials containing reference SRP waste compositions will be supplied by respective waste form developers in FY 1981 for testing by MCC methods. Additional waste materials, however, will be characterized by the MCC and other programs.

Data generated by the MCC will be reviewed by the MRB for conformance to test methods. Both the approved test methods and data will be incorporated into the Materials Handbook (Section 7.2).

While test methods will be developed for current concerns, additional areas may also exist, and these areas or conditions need to be identified. To aid in this identification, the MCC will perform exploratory tests on materials to determine if a particular condition or property is significant and warrants further study and standard test development. One such area is the potential synergistic effects of β and γ radiation with α radiations. Development needs may also be identified that are beyond the MCC scope and these will be communicated as appropriate.

Activity Schedule

The MCC activity schedule is shown in Figure 3.3 (program milestones are discussed in Section 3.6). The schedule shows that waste form materials are receiving early emphasis. The development of basic test methods will be

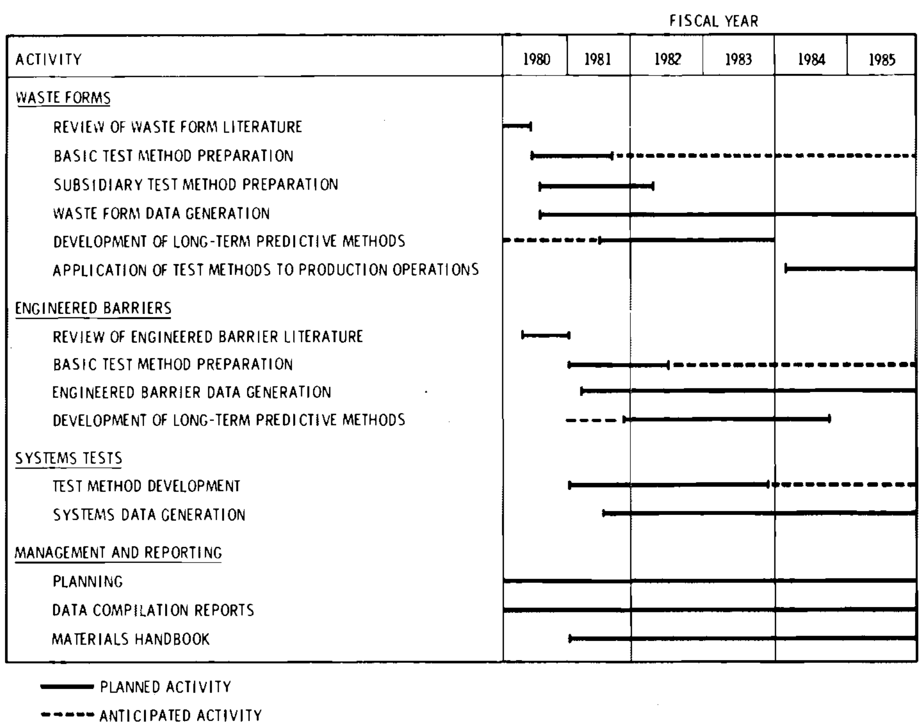

FIGURE 3.3. Materials Characterization Center Activity Schedule

completed in mid-FY 1981. Test methods that are necessary to support specific measurements within the basic test methods will be in FY-1982. (Details are discussed in Section 4.1.) Test methods and data generation are directed in the near term to providing data on pertinent properties of significant waste forms to SRP for their FY-1982 decisions. Applicability to other waste forms is also being considered. Emphasis will then shift to experimental development of predictive test methods, which will be capable of evaluating long-term behavior, and should support design and licensing activities. Later activities will provide quality verification methods for production materials. If necessary, the MCC can participate as a third party with the waste processors and repositories operators on evaluating production materials characteristics.

Engineered barrier materials are also receiving early emphasis; but due to the limited current state of waste package design, the selection of appropriate basic test methods is not expected to be completed until mid-FY 1982. Data generation will follow approval of the basic methods. The development of predictive test methods will also be undertaken. See Section 5 for a more detailed description.

The combining of engineered barriers, waste form materials, and repository environments creates a waste materials "system." Ultimately, it is the performance of a system as a whole that is important. Current draft NRC criteria (10 CFR 60)[a] may be based on the total system performance. Consequently, the MCC will begin developing test methods that can be used to determine and predict the behavior of waste materials systems in FY 1981. Details are contained in Section 6.0.

3.3.2 Waste Type and Schedule

As noted in Section 3.3.1, the first phase of activities will be directed toward high-level defense wastes. Spent fuel will also be considered to the extent possible in the early procedures. During FY 1981 the TRU wastes materials will receive increased emphasis along with HLW behavior during interim storage and transportation.

(a) Code of Federal Regulations. Title 10, Part 60.

It is anticipated that the major factors in the selection of a processed waste form will be its degree of waste containment and stability. Therefore, these factors will receive greater attention. Physical and mechanical properties must also be considered and evaluated, but they will receive less emphasis since many existing standard methods may be applicable.

3.4 TEST METHOD DEVELOPMENT AND DATA QUALIFICATIONS

The major efforts of the MCC are development and review of test methods and data. It is the purpose of this subsection to outline the procedural steps for developing and obtaining MRB approval of test methods and waste materials data for both the MCC and external groups.

3.4.1 MCC-Developed Test methods

The steps that will be used to develop a test method within the MCC are shown in Figure 3.4. The development process begins with the identification of applicable criteria and storage conditions and review of methods reported in the literature. The use of applicable criteria and environmental conditions in selecting the properties for test development and in developing the most effective test is highly desirable. Since these are not currently known, the tests will be generic. The literature reviews will be supplemented by workshops where experts from throughout the U.S. will meet to discuss specific technical areas such as leaching, radiation damage, and thermal stability. The general approach and specific methods which the MCC should propose to the MRB will also be discussed at the workshops.

From these reviews and workshops, a draft test method will be selected. Internal technical reviews of the method and its potential uncertainties would then occur. Where necessary, a preliminary experimental effort will be planned and executed to identify and reduce the unknowns or uncertainties in the method.

The final review, which may include external experts, will determine whether: 1) the method is to be submitted to the MRB; 2) a round robin is to be conducted to further verify the method and obtain supporting documentation and greater statistical bases; or 3) new variables need to be considered in an

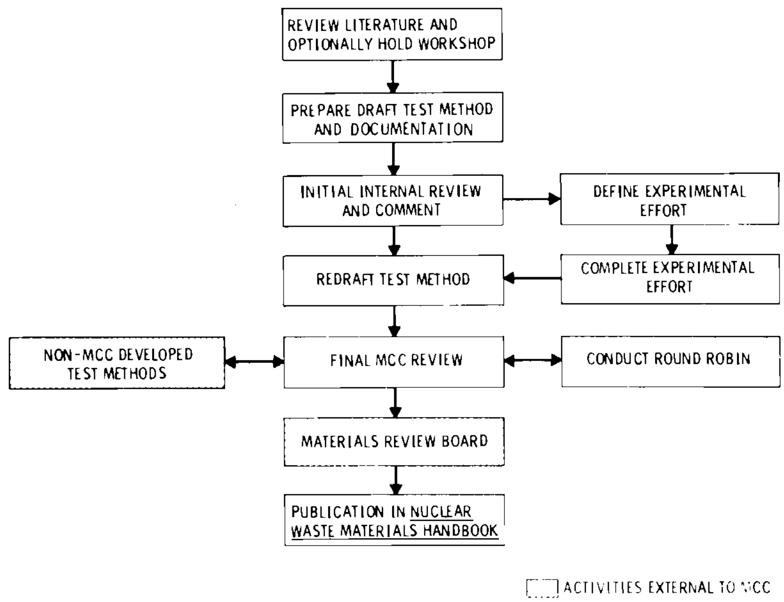

FIGURE 3.4. Test Method Flowchart

additional experimental effort. When the method is submitted to the MRB for review, the MRB will either recommend the method's adoption or return it to the MCC for further development. Once approved by the MRB, the method will be published as part of the Materials Handbook.

3.4.2 Externally Developed Test Methods

Other groups and organizations will also be developing and using test methods, some of which will need to be incorporated into the Materials Handbook. The MCC will function as a clearinghouse for such methods, by providing a final review and organizing the documentation before submittal to the MRB.

3.4.3 MCC-Developed Test Data

Data for the Materials Handbook will be obtained by approved test methods. The process will, as shown in Figure 3.5, begin by a request for data by appropriate programs or recognition by the MCC that specific data are needed. The MCC, upon agreement with the lead sites to obtain the data, will prepare a test plan to document the requirements and identify the test method. The test plan

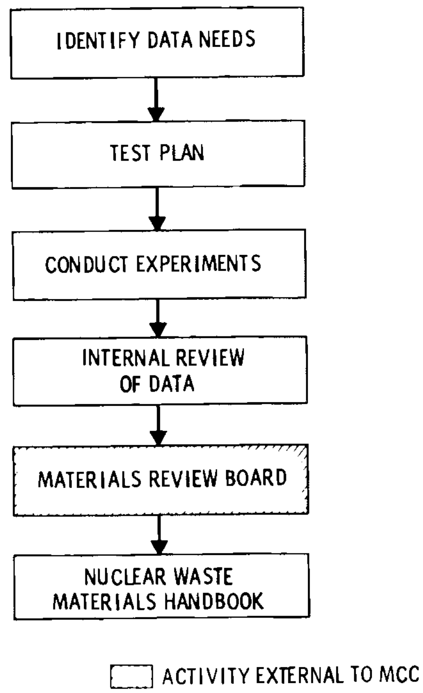

FIGURE 3.5. Flowchart for MCC-Developed Test Data

will be reviewed by MCC management and the external requestor of data (if appropriate). Data generation will follow the test plan. Final internal review of the data and test plan will be completed to ensure that data were obtained by an approved method before submittal to the MRB. After review and approval by the MRB, the data will be published in the Materials Handbook.

3.4.4 Externally Generated Test Data

Data generated externally from the MCC and submitted for incorporation into the Materials Handbook will be reviewed by the MCC for conformance to approved test methods and will be verified by separate MCC tests where appropriate before submittal to the MRB. After MRB approval, the data will be incorporated into the Materials Handbook.

3.4.5 Evaluation of Methods and Data

Supporting documentation will be provided with test methods and data that are submitted to the MRB. A significant part of the documentation will be the statistical basis for the method with the precision defined. Data will be presented to allow the values to be verified. Obtaining these data will be a major part of the initial experimental efforts of the MCC.

3.5 BUDGET

Budget projections for the MCC are given in Tables 3.1 and 3.2. Table 3.1 provides a summary of the base operating costs and capital equipment costs through 1985 to be provided by SRL. Table 3.2 provides task-by-task detail through 1983. These budgets are consistent with the previous WPAS. It is anticipated that these budgets will be modified as more experience is obtained. Additional funds will be provided by the TRU, low-level waste, waste isolation, and other programs for specific characterization activities.

TABLE 3.1. Nuclear Waste Materials Characterization Center Budgets for FY 1980-85 (Dollars in Thousands)

	Fiscal Year					
Funds	1980	1981	1982	1983	1984	1985
Operating	$2000	$3000	$3200	$3500	$3500	$3500
Capital	$ 500	$ 415	$ 300	$ 300	$ 300	$ 300

TABLE 3.2. Nuclear Waste Materials Characterization Center

Program Element	1980	1981	1982	1983
Administration	$ 550	$ 500	$ 400	$ 400
Waste Form	900	1200	1200	1000
Engineered Barriers	350	750	900	1000
Systems Tests		350	500	850
Data Dissemination	200	200	200	200
Total	$2000	$3000	$3200	$3500

Major capital equipment items for procurement during 1980 include: 1) a shielded X-ray diffraction system for fully radioactive materials; 2) an induction-coupled plasma for emission spectrophotometer chemical analysis of highly radioactive materials; and 3) a scanning transmission electron microscope (only partial support will be needed).

During 1981, major emphasis will be on 1) a system for testing barrier materials at high temperatures and high radiation fields; and 2) a scanning electron microscope for high-level radioactive waste materials.

3.6 MILESTONES

The major milestones for FY 1980-85 are shown in Figure 3.6 and discussed in Section 3.6.1 and the detailed milestones for FY 1980 are shown in Figure 3.7 and discussed in Section 3.6.2

3.6.1 Administration and Planning

The MCC Program Plan will be updated each September to reflect the detailed needs and planning for the coming year.

Waste Forms

The basic set of test methods are identified and described in Section 4.1.1. These test methods are intended to provide a base by which materials properties and characteristics of major interest for use in waste containment can be evaluated.

The subsidiary set of test methods will be defined as the basic set of test methods are developed. The test methods identified in Section 4.1.2 will be included. Subsidiary methods will be referenced in the basic set and will provide greater detail on how measurements are to be made.

The applicability of the basic set of test methods to spent fuel will be confirmed with ONWI support and funding.

Characterization data on waste forms of interest will be obtained by the basic set of test methods to support SRL waste form selection decisions in FY 1982.

Predictive test methods will provide a method whereby waste materials characteristics and properties can be evaluated and extrapolated to time periods of up to 10^4yr and possibly beyond. Chemical durability and radiation and thermal stability will be characteristics of major interest. Both long-term and accelerated methods will be considered and evaluated.

Quality control methods to monitor the product from a waste processing plant will be needed about the end of FY 1984. This assumes that decisions on the waste form and its production process are made by FY 1982.

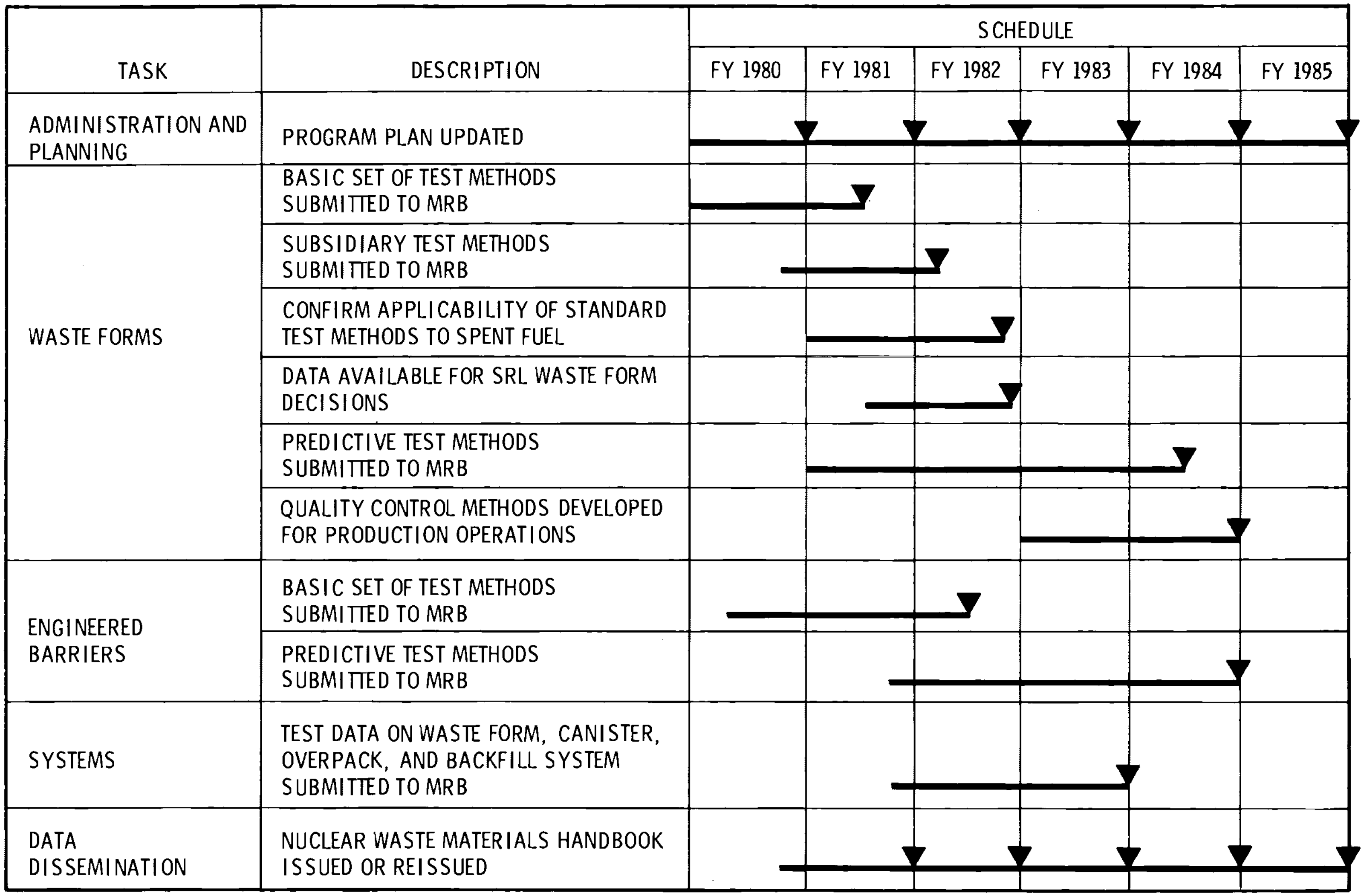

FIGURE 3.6. FY 1980-1985 Major Milestones for the Materials Characterization Center

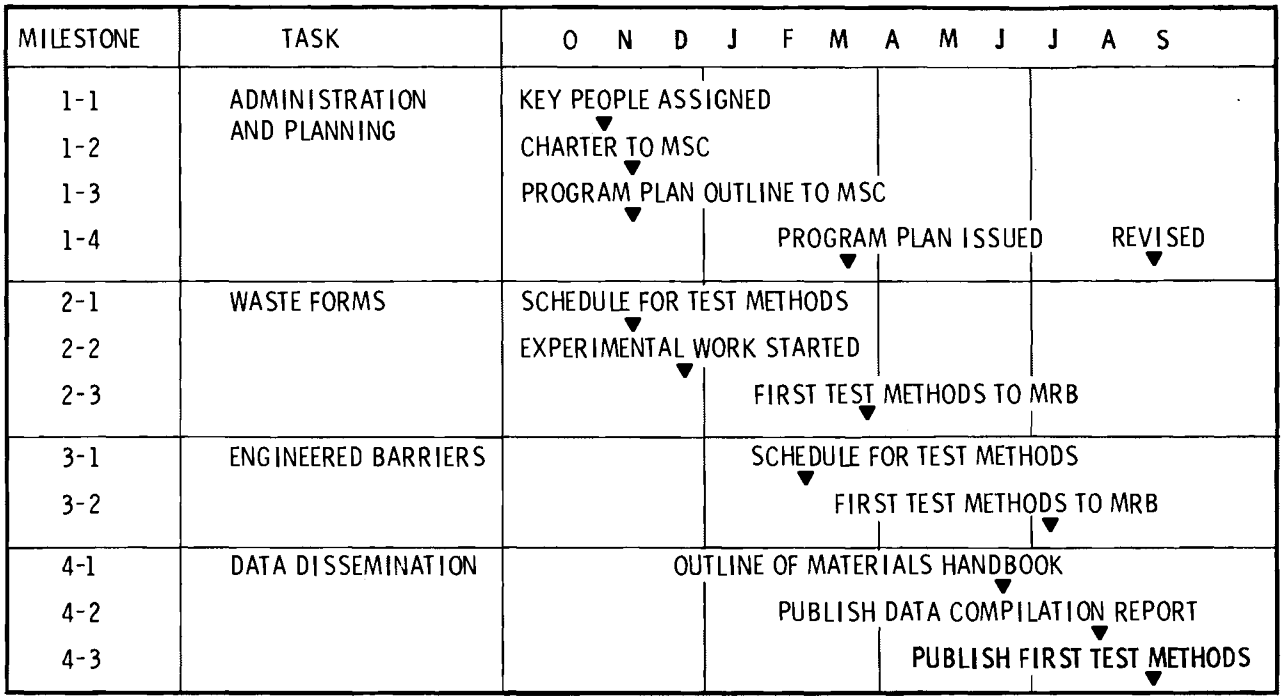

FIGURE 3.7. FY 1980 Milestones for the Materials Characterization Center

Engineered Barriers

The basic set of test methods are identified and described in Section 5.1.2. These methods are intended to provide a base by which properties and characteristics of major interest to barrier containment functions can be evaluated. These methods will be completed in April 1982.

Predictive test methods will provide a method by which characteristics and properties of barrier materials can be evaluated and extrapolated to time periods of 10^3yr and possibly beyond.

Systems

Laboratory and bench-scale systems tests will address the ability of the combined components of waste form and barriers to meet performance requirements and will identify interactions between the various components. Initial data on systems behavior will be submitted to the MRB by September of 1983.

Data Dissemination

The Materials Handbook will be initially issued in September 1981. The handbook at this point should contain the basic waste form test methods, some waste form data, and some test methods on engineered barriers. It will be updated periodically with additional data and test methods. The September 1982 issue will include data to support the SRL decision on waste materials.

3.6.2 Milestones for FY 1980

The milestones for FY 1980 show that the MCC will be fully operational September 1980 and will provide materials data for SRP's waste form selection in FY 1982. A listing of the milestones is shown in Figure 3.7. The milestones and their status are discussed briefly below. Further schedule details are shown in Sections 4, 5, and 6.

- Milestone 1.1. Key people, including program manager, associate program manager, and task leaders were assigned.
- Milestone 1.2. The MCC Charter (Section 1.1) was submitted and approved by the MSC at DOE Headquarters.
- Milestone 1.3. The initial outline of this program plan was submitted to the MSC with the MCC Charter.
- Milestone 1.4. This initial plan reflects the needs of the HLW Program at Savannah River, the TRU Waste Program at Rocky Flats, and ONWI. Revised plans will also include the needs of the Transportation Lead Site at Sandia, low-level waste programs at EG&G and Oak Ridge National Laboratory. The issuing of this program plan to DOE's Richland Operations Office completes this milestone. The program plan will undergo additional reviews after publication. The specific needs of other lead sites will be incorporated by September 1980.
- Milestone 2.1. As part of the program planning process, schedules for the various waste form test methods were developed to incorporate into this document and for program implementation.

- Milestone 2.2. Experimental work to support the development of test methods identified in Milestone 2.1 was started.
- Milestone 2.3. As part of the schedule for test methods, three methods were identified for initial development by March 31, 1980. At least one test method will be submitted to the MRB by then; the other methods will be submitted in April 1980.
- Milestone 3.1. A schedule for engineered barrier test methods has been developed and is incorporated as part of this program plan.
- Milestone 3.2. Development of several test methods will be started, at least one of which will be submitted to the MRB by July 1980.
- Milestone 4.1. A format and outline of the Materials Handbook to be issued in September 1981 will be developed by June 1980. This will allow the supporting information necessary for the Materials Handbook to be generated.
- Milestone 4.2. The compilation report on waste form data from literature reviews will be published and available by August 1980.
- Milestone 4.3. The tests methods approved by the MRB through July 1980 will be published at this time.

3.7 QUALITY ASSURANCE

The MCC mission requires quality data which thus requires that quality assurance methods be applied to MCC activities. Data for the Materials Handbook will necessitate that equipment be calibrated and measurements be standardized. Precision will be established using statistical analyses.

3.8 MANAGEMENT REPORTS

The MCC will use a combination of monthly, quarterly, and topical reports to document the activities and progress of the MCC. The reporting requirements will be modified as needed to provide the necessary level of communication. Monthly management reports are intended to inform program managers and monitors about general progress, milestones, budget status, and potential problems.

Oral presentations will also be given upon request to DOE management, including Richland Operations Office, Savannah River Laboratory, and the MSC. Additional program reviews will also be held as requested. Data compliation reports, a Materials Handbook, a newsletter, and information meetings discussed in Section 7.0 are intended as technical reports. Additional technical reports will include open-literature publications and presentations at national meetings. These will be prepared by the MCC as appropriate results are available.

4.0 WASTE FORM MATERIALS CHARACTERIZATION

4.1 STANDARD TEST METHOD DEVELOPMENT

Test method development has been divided into three categories: basic, subsidiary, and predictive. The basic test methods are described in Section 4.1.1 to address the characteristics and properties of major interest in the comparison of different waste forms. These test methods are divided into five major subareas: 1) chemical durability, 2) radiation stability, 3) thermal stability, 4) physical and mechanical properties, and 5) specimen description and analysis.

The subsidiary test methods provide details on how measurements such as microstructural evaluation and chemical analysis are to be performed. Additional detail is covered in Section 4.1.2

The predictive test methods development will be aimed at greater understanding of the material behavior so that extrapolation to long-term behavior can be made with greater confidance. Long-term tests, accelerated tests, and mechanistic modeling will be evaluated as methods to predict chemical durability and radiation, thermal, and mechanical stability.

4.1.1 Basic Test Method Development

Each test method will be developed using a consistent plan to ensure that complete packages, containing all of the required supporting data, are presented to the MRB. The steps in the methodology that will be used for test method development were described in Section 3.4. The waste form measurement methods required for chemical durability, radiation stability, thermal stability, mechanical and physical properties, and sample specimen selection and description are discussed in more detail in the following sections. Three reference waste forms--a glass, a hot-pressed ceramic, and a concrete--will be used in the initial development of the test methods.

The standard tests will be selected to provide data that can be related to the criteria described in Section 2.3. Since criteria are still being formulated, some testing requirements will change. Nevertheless, for the MCC to meet its near-term goals, the test development schedule shown in Figure 4.1 has been developed. This schedule will be reviewed frequently and modified as

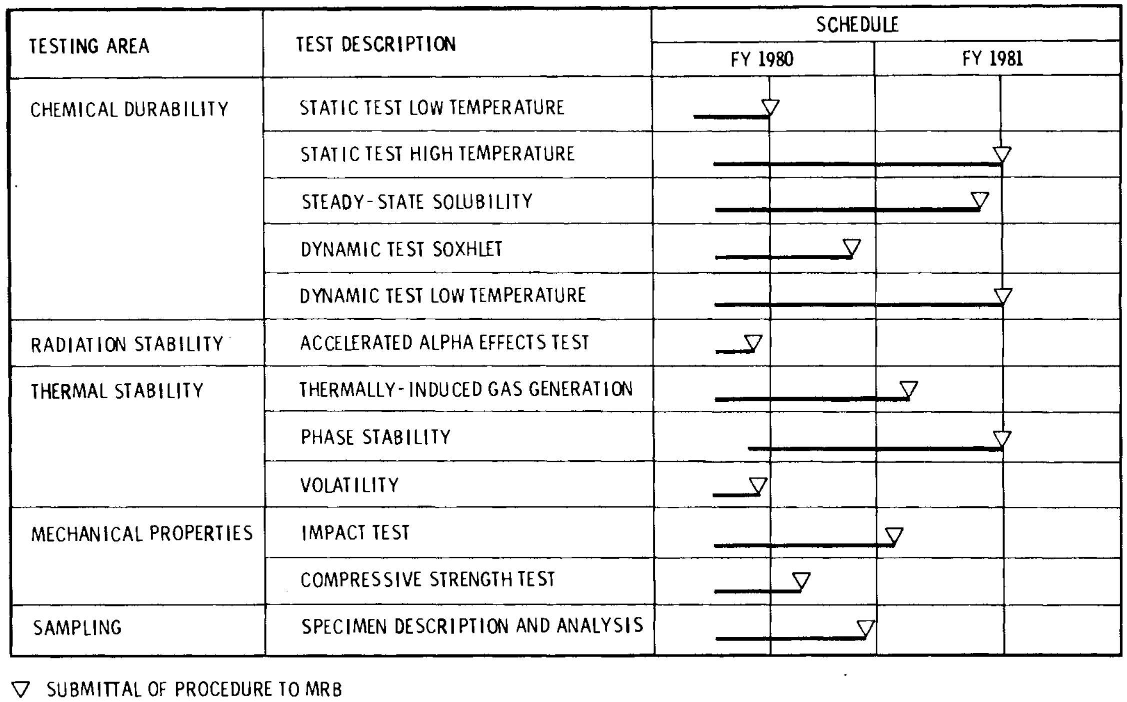

FIGURE 4.1. Near-Term Schedule for Development of Basic Waste Form Test Methods

required to ensure that it continues to meet the current needs of the waste management community.

Chemical Durability

Chemical durability of waste forms is usually expressd in terms of a leach rate, which is generally accepted as the most important property measured on waste forms. A large body of such data exists, which has been collected over the more than 20 yr during which candidate waste forms have been under development. Unfortunately, differences in experimental procedures make correlation and comparison of these data difficult. Consequently, a major function of the MCC is to provide a standardized method for assessing the chemical durability of waste forms.

Several tests will be required to adequately characterize leaching of waste forms. Since the conditions that a waste form will be exposed to in a repository are not well defined, the test methods will be generic and provide flexibility. As ONWI defines repository conditions and as specific sites are selected, the test conditions can be further defined and become more specific. Two water flow conditions that may exist with respect to leaching are 1) water present but no flow (i.e., static) and 2) flowing water at variable rates. For the no-flow condition, waste forms should be characterized for the kinetic approach to the solubility or steady-state limits. Under flowing conditions, the effects of flow rate and groundwater composition on leaching will be determined.

Temperatures to be used in the test methods will emphasize the expected conditions but will also consider worst case conditions. Temperatures may be quite high (250^{o}C) during the early years in a repository, but will be less than 100^{o}C for the periods when water contact is more likely. With the differences in testing requirements above 100^{o}C, two methods will be required for each water flow condition. These requirements are shown by various methods indicated in Figure 4.1

Use of the test methods and data will allow comparison of various waste forms. Since different sets of conditions are anticipated to provide different relative performance values for waste forms, it will be important to generate sufficient data under a variety of conditions so that a reliable evaluation can be made. The interactions of water with waste forms, typical repository materials, and engineered barriers are considered under systems tests (Section 6.0).

Radiation Stability

Nuclear waste forms will be subjected to high self-irradiation doses that may, over the long-term, adversely affect material properties, such as mechanical integrity, leach rate, and gas generation rate. A method of accelerating long-term radiation effects into an experimentally practical time frame will be used. Since the major source of solid-state radiation effects is the alpha-recoil reaction, the procedure to evaluate radiation effects on HLW forms will consist of doping test specimens with short-lived alpha-emitters and measuring changes in crystal and amorphous phases, leach rate, density, stored energy, and mechanical strength as a function of accumulated dose.

Other radiation effects tests will be developed later as required. For instance, some candidate non-HLW forms undergo significant physical changes and generate gases even in beta-gamma fields. A standard gamma radiation test may be developed for these waste forms. Ion acceleration methods have also been utilized to induce radiation effects. Comparisons of ion beam and actinide doping methods will also be completed.

Thermal Stability

The intent of the thermal stability criterion in 10 CFR Part 50, Appendix F, is to prevent undue pressurization of the canister by thermally induced gas release from the waste form. One standard test will evaluate the gas release from candidate waste forms by direct measurement at a series of temperatures. A second test method will evaluate the high-temperature stability of waste forms by determining elemental vaporization from waste forms during an isothermal period.

The stability of crystaline or amorphous phases within a waste form at moderate temperatures for long time periods needs to be evaluated to allow projection of both chemical and physical changes. Currently used methods of determining stability will be evaluated and standard test methods developed. Both hydrous and anhydrous environments will be considered in establishing maximum allowable storage temperatures.

Mechanical and Physical Properties

The mechanical properties of waste forms can be important in the event of severe accidents, e.g., transportation vehicle accidents or impacts sustained during interim storage and handling operations. For accident analyses involving a breached canister, data are needed from which to estimate the release of respirable or dispersible particles. In other areas, such as understanding the importance of residual stresses in multiphase ceramic waste forms because of their cooling cycle or radiation-induced density changes, it is desirable to have a test procedure available for measuring mechanical properties. Consequently, test methods which were developed in previous studies, are being evaluated. The tests involved will be: 1) an impact test followed by measurement of the particle size distribution and 2) a diametral-compression (or splitting-tensile) test-to-failure. The surface area of a waste can be important in determining the total quantity of material leachable in specific time periods. Therefore, test methods to determine surface area and particle size of large prototype material will require development. A major factor in determining the surface area and particle size of a large ceramic waste form will be the thermal shock sensitivity of the material. Tests in these areas will be developed after the basic set of test methods.

Many common physical properties will be measured on candidate waste forms, such as

- density
- thermal expansion
- thermal conductivity
- porosity

It is expected that existing standard procedures can be used to measure these properties and that the MCC will not go through the complete test development procedure described in Section 3.4. If MCC test method development is required, it will be scheduled as part of the subsidiary test methods.

Sample Specimen Selection and Description

The acceptance of a property measurement made on a given waste material depends on two factors. First, the test method and conditions must be accepted by interested parties. Second, and equally important, the material on which the measurement is made must be defined in sufficient detail to allow reproducibility of the result. Thus, sample specimen selection and description will be a vital part of all property measurement procedures established by the MCC.

Material definition is particularly difficult with nuclear waste forms because of their chemical complexity. High-level waste usually contains 30 to 40 different elements in significant concentrations; the matrix materials needed to make a chemically inert waste form add several more elements. Several processing steps may be involved in manufacturing the waste form, each of which may affect the final properties. The actual waste form will be self-heating and self-irradiating, which may change some of its properties as a function of time. Furthermore, nonuniformities may be introduced in processing. Therefore details on methods of sampling and sample preparation will be necessary. Methods will be developed by the MCC and included in its test procedures to assure that the test specimens are adequately described. Data will not be submitted to the MRB for inclusion in the Materials Handbook unless it includes an adequate specimen description. It is anticipated that the description will be based on a combination of chemical analysis, microstructural examination, phase identification, some physical properties, and documentation of the preparation procedure.

4.1.2 Subsidiary Test Methods

Some of the tests methods described above require that one or more subsidiary measurements be made. These subsidiary measurements will require standardization also. In addition to those shown in Figure 4.1, examples of standard test methods that will be developed to meet the subsidiary measurement requirements include:

- Optical microstructural examination
- SEM evaluation
- STEM evaluation
- X-ray diffraction evaluation
- Solution analysis methods

Other physical and mechanical property test methods that may also need to be developed will be included in this set.

4.1.3 Predictive Test Methods

Many waste form questions relate to what will happen to these forms and how they will behave for longer time periods than is experimentally possible to verify directly (i.e., 10^2-10^4 yr). It is therefore necessary to develop methods which will be extrapolatable to the periods of interest. Some of the basic methods will provide useful data, however development periods may not be sufficient to provide test methods of the desired prediction accuracy.

Long-time experiments, simulation methods (i.e., use higher temperature, shorter half-lived isotopes, change chemistry), and increased scientific understanding to allow mechanistic modeling will be developed to improve the predictive accuracy of test methods. The actual waste form will be self-heating and self-irradiating, which may change some of its properties as a function of time.

Test methods which address chemical durability, radiation stability, thermal stability, and mechanical stability will be planned in greater detail in FY 1981.

4.2 MATERIALS TESTING

After the waste form standard tests are approved by the MRB, they will be available for use in other laboratories. An initial responsibility of the MCC will be to assure that adequate data, obtained by the standard tests, will be available for use by SRP in arriving at their decisions on waste forms for defense HLW. It is expected that some of the testing will be done by the various waste form developers. The additional testing will be done by the MCC. The MCC will work closely with SRP to assure that samples of the candidate waste forms are available for standard testing.

Specimens of all of the candidate HLW waste forms prepared with simulated SRL waste will be required by the MCC by March 1, 1981. Short-term test data on the candidate waste forms will be submitted to the MRB by September 1981. Longer term test data (up to 1 yr) will also be submitted to the MRB and available for use in the SRP waste form decisions by September 1982.

Decisions on waste forms will, in part, be based on comparison of the materials properties data generated by the MCC standard tests. The comparisons will be facilitated if the same waste compositions are used in each of the candidate waste forms. Therefore, the MCC will, in conjunction with SRP, select one or more standard waste compositions and direct the data acquisition test plan toward obtaining comparisons on a common waste composition basis.

5.0 ENGINEERED BARRIER MATERIALS CHARACTERIZATION

The barriers to waste dispersion that lie between the waste form and the geologic medium are defined as engineered barriers. The waste-containing canister, the overpack, the hole sleeve, and the backfill medium could all be considered engineered barriers. The repository shafts and boreholes may be sealed by plugs of engineered materials, some of which may be similar to candidate backfill materials. Ordinarily, barriers are not expected to fail in a repository environment for long periods of time.

The possibility of a barrier failure constitutes the rationale for characterizing candidate engineered barrier materials. Such failures may be as simple as mechanical failure during handling, but could include more complex failures, such as those caused by corrosion and stress over long exposures to radiation, heat, stress and other complex environmental conditions.

A broad approach is essential during the early phase of this task to systematize studies and evaluate test procedures. Many properties of materials are expected to be adequately specified by known procedures; others will require new or modified procedures. The two stages in engineered barrier materials characterization are: 1) the development of standard test methods and 2) the generation of data through the use of the standard test methods.

5.1 STANDARD TEST METHOD DEVELOPMENT

Standard tests to define the properties of engineered barrier materials are needed to aid in selecting and optimizing materials for use as barriers and in providing data for use in materials selection, design, and licensing of engineered barrier systems.

Metals, ceramics, polymers, graphite, concrete, clays, grouts, zeolites, and asphaltic materials are each a class of barrier materials. Specific candidate barrier materials will be identified within each of the major classes. Each class has particular failure modes and therefore requires different procedures for characterization. Inclusion of specific materials in the MCC plans will ensure that an identified material class is represented by candidate materials. Such candidate materials are likely to be commercially available materials.

The potential failure modes will be identified for each class of material. Test methods will be developed accordingly. Failure is defined as an event or sequences of events that results in unsatisfactory barrier performance and, in general, signals the end of the useful life of the barrier. The identification of failure modes is important in that such failure modes will define the allowable barrier stresses and environmental conditions that can be imposed on a given barrier within the allowable times to failure. These failure modes will also determine required testing facilities, analytical capabilities that must be used, and the applicability of existing codes and test procedures, such as ASTM and ASME standards.

5.1.1 Selection of Tests

The standard tests will be selected and developed to provide data that can be related to current (Section 2.3) and future criteria. It will be necessary, for the present, to assume some of the barrier requirements and to develop standard methods based upon current knowledge and draft criteria since material specification and criteria are not available. The test methods will address both normal and accident conditions. Future criteria may require the modification of approved test methods and generation of additional data.

A schedule for development of proposed test methods is shown in Figure 5.1. This schedule will be updated as engineered barrier materials are further developed and selected and as the need for data is more fully defined.

5.1.2 Test Method Development

The procedure that will be used to develop test methods was described in Section 3.4. For engineered barrier materials, the test methods will be divided into the categories of containment barriers (canisters, overpacks, and borehole sleeves) and backfill barriers (material used to fill void space in boreholes around canisters and to fill shafts and tunnels of repositories).

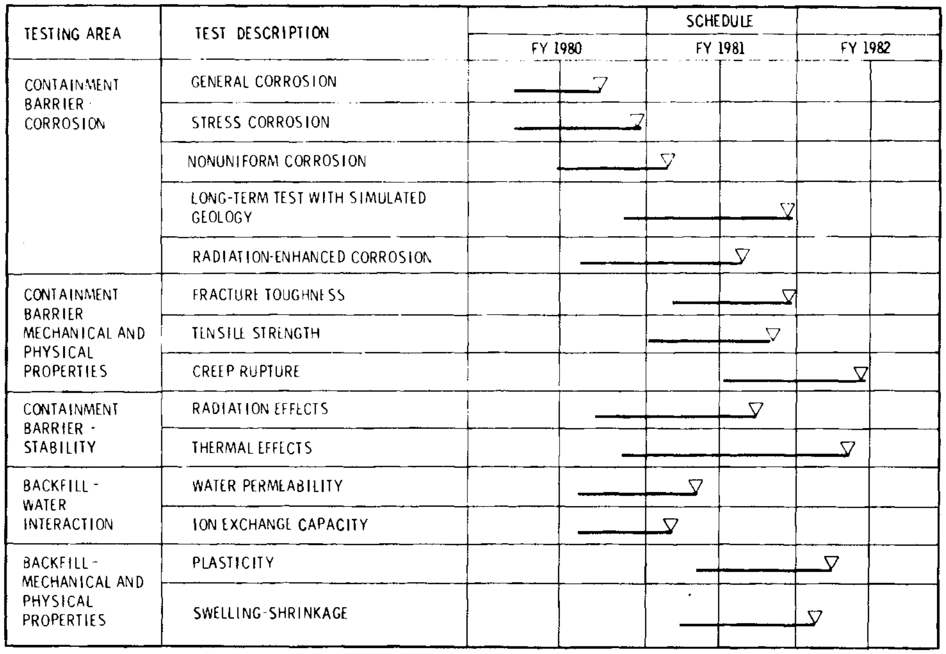

FIGURE 5.1. Schedule for Development of Engineered Barrier Test Methods

Sources of performance codes will be searched. Sources of such codes include ASTM, ASME, ANSI, AWS, API and ANS. These codes will be evaluated for relevance to barrier materials. Evaluation of such codes will be intensive during the early part of the program and will be given continued consideration throughout the program.

For containment barriers, the areas for test method development are: 1) chemical durability, 2) mechanical and physical properties, and 3) phase stability. For backfill materials, the test method areas are: 1) water interactions and 2) mechanical and physical properties.

Chemical Durability - Containment Barriers

The chemical durability of canisters and overpacks is usually given as an overall average corrosion rate, expressed as a penetration rate. Of equal or greater importance in considering potential failures of the barrier is stress corrosion cracking or pitting reactions in localized areas. Since the purpose of the containment barrier is to provide total containment, the breaching of the containment before the specified time even with a crack or pit would not conform to the proposed criteria (Section 2.3). While it will eventually be important to evaluate the release rates through pits or cracks, the initial emphasis will be on the determination of the period of unfailed containment. As noted in Figure 5.1, this will involve the establishment of scoping test methods for general corrosion, stress corrosion, and other local accelerated corrosion mechanisms. It will also be necessary to develop a method to provide good prediction of barrier performance for long periods, i.e., about 1000 yr (Section 2.3).

Gamma-radiation environments also accelerate corrosion of metals and have been shown to have effects on organic materials. Therefore, test methods will have to be developed to assess radiation effects.

Mechanical and Physical Properties - Containment Barriers

The mechanical and physical properties of containment barriers are important in assessing the effects of accidents during waste handling and of geologic stresses on the waste package after emplacement. Since most of these perties are secondary to the corrosion properties and are being studied for most materials in diverse research projects, it may not be necessary to develop special test methods. Initially, major emphasis will be to review existing ASTM and other standards for direct application.

Fracture toughness is an important property to consider because many potential accidents during the preparation and handling stages may involve a mechanical impact. Other fracture properties may also need to be evaluated. Tensile strength data are used for design and also used to evaluate effects such as radiation and elevated temperature exposures. Creep rupture is important in the evaluation of long-term internal pressurization and geologic stress on the barrier.

Typical physical properties are discussed for waste forms and methods in Section 4.1.2. These same methods may also be applied to barrier materials and will likely be currently developed and recognized methods.

Stability - Containment Barriers

Properties can change significantly because of heat and radiation effects, both of which will be present in repository environments. These conditions have not yet been specified.

Radiation effects for containment barrier materials will be concerned primarily with gamma radiation since alpha and beta radiation will be essentially contained in the waste form. Neutron effects will also be reviewed. Radiation effects on corrosion rates were discussed previously. Density and mechanical properties will need to be evaluated. The properties or effects evaluated for ceramics, metals, and polymers will vary, but we must be able to compare them.

Thermal effects test methods will be concerned with phase stability of containment barriers in repository environments. Since some materials may be metastable at the relatively low repository storage temperatures, evaluation of stability will be important and will require long testing periods.

Water Interactions of Backfills

The water interactions of backfill and borehole plugging materials have at least two areas of importance: the permeability of water through the backfill and the interactions of the backfill materials, waste form, and leachate. Other areas such as chemical buffering behavior develop importance as the role of the backfill materials is better defined and utilized in potential designs. Water permeability through a backfill can limit waste leaching and migration. Current techniques used to measure permeability of geologic materials and borehole plugging materials will be evaluated first for applicability to backfill materials.

Ion exchange capacity and behavior are being studied extensively in programs such as Waste Rock Interaction Technology (WRIT) for application to repository materials. Appropriate methods from these and other programs should be applicable to backfill materials for inclusion in the Materials Handbook.

Mechanical and Physical Properties of Backfills

The mechanical and physical properties important to backfills will depend on performance requirements. Plasticity and swelling or shrinking behavior of the backfill will probably be significant. Plasticity will be important in allowing the canister or borehole plug and geologic formation to shift with respect to each other without rupture of the canister or backfill. As the need for knowledge of backfill behavior becomes apparent, existing methods for clays and other materials will be evaluated.

Information on swelling and shrinkage behavior will be important since the development of shrinkage cracks in the backfill or borehole plug would result in the potential for higher water flow rate and waste releases. Significant swelling could stress the canister and overpack and increase their susceptibility to stress corrosion and creep rupture problems.

Subsidiary Methods

The development of standard test methods requires that subsidiary test measurements be developed for barrier materials. Some of these may be the same as for waste forms (Section 4.1.1). Standard reference materials will be used where possible to validate such measurements. Standard microstructural and chemical methods will be used to characterize samples used in standard tests. Anticipated techniques that will be considered for standard test method development for microstructural analysis are metallography with light and scanning electron microscopy. Techniques for composition and microchemical analysis will include x-ray diffraction, x-ray fluorescence, electron probe microanalysis, scanning transmission electron microscopy, and surface-sensitive techniques such as Auger spectroscopy and electron spectroscopy for chemical analysis.

5.2 DATA GENERATION

The first sets of data on engineered barrier materials will be useful both for engineering designs and for selection of materials for more detailed evaluation. Currently, materials and requirements for engineered barriers are being defined. Several programs including Basalt Waste Isolation Project (BWIP), the High Level Waste Immobilization Program (HLWIP), and the Waste Isolation Pilot Plant (WIPP) have evaluation tasks for containment barriers. Major efforts on backfill materials are just beginning this year in other programs. It is expected that materials and critical properties will be identified in these programs. The MCC will support these and other programs by review of their test methods and data and by consultation in selection of standard materials and test methods.

6.0 SYSTEMS TESTS

Systems tests, as currently defined in the context of the MCC, are tests in which selected waste form and engineered-barrier components are combined to determine interactions and behavior. Systems tests can be viewed as validation tests. Their major purpose is to verify behavior that has been deduced from simpler tests in which individual components, and effects such as temperature and radiation, were examined individually. A corollary purpose is to ensure that nothing unexpected occurs when the components of the system are combined. Systems tests are a vital culmination to a testing sequence that starts with simple scoping tests and becomes more complicated by introducing more and more parameters.

In many instances, the systems tests will be elaborate and the predefinition of standard test methods of individual components may not be applicable. Indeed, some of the tests may be one of a kind. The systems data, in many cases, will be the final testing of the mathematical models that are used to predict the overall behavior of the multibarrier waste management system. It is important that data from systems tests be included in the Materials Handbook.

Examples of the waste management systems and subsystems that may require testing as units are given in Table 6.1. These systems all contain the waste form and the canister. The tests will either monitor the release and migration of radionuclides from the waste form or the effects on system properties that are governed, at least to some extent, by the chemistry and radionuclide content of the waste form.

Initially, small-scale systems tests will be done in the laboratory. Scale-up tests will determine the ultimate size of tests required. In some cases, it will be possible to correlate the scale-up tests directly to the behavior of the materials in full-scale, in-situ field tests conducted in other programs. In many cases, however, particularly in the nonstandard conditions tests and test-to-failure modes, this will not be possible. Then reliance for predicting the future behavior of waste materials in the repository system will be placed on having knowledge of the basic mechanisms at work as determined

TABLE 6.1. Systems Potentially Requiring Testing

System	Situation To Be Simulated in Tests
1. Waste form plus canister	Interim surface storage of full-sized materials; standard and nonstandard conditions
2. Waste form plus canister plus shipping cask	Accident involving impact and fire
3. Waste forms plus canister (plus overpack)	Accidental drops, including repository shaft accidents
4. Waste form plus canister (plus overpack) plus repository rock	First 1000-yr storage in geologic repository; standard and non-standard conditions
5. Canister (plus overpack) plus backfill plus repository rock	Beyond 1000-yr storage in geologic repository; standard and non-standard conditions

in Sections 4 and 5 and basic research efforts corroborated with the laboratory systems tests.

One function of the MCC will be to ensure that proper documentation is obtained at all stages of systems tests. The MCC will only perform systems tests for data needs that are not being met by other programs.

Data generated by other programs may be submitted through the MCC to the MRB. For instance, laboratory-scale systems tests in which miniature canisters of waste glass surrounded by candidate repository rock are subjected to hydrothermal conditions are being conducted by the WRIT program at PNL. The MCC will upon request review the WRIT data for submission to the MRB for inclusion in the Materials Handbook; after MRB approval, the MCC may then use the WRIT-developed systems test methods to test other materials not included in the WRIT program.

6.1 TIMING AND SCHEDULE

Initially, the MCC will emphasize obtaining basic property measurements on individual materials within the waste management system as discussed in

Sections 4 and 5. However, planning for incorporating materials properties from systems testing within the program will also begin in FY 1980; such testing will become a significant part of the program in FY 1981. Key proposed milestones for these and subsequent years are shown in Figure 6.1.

6.1.1 Plans for FY 1980

The MCC systems testing program will be coordinated with existing research and development programs involving initial laboratory-scale systems testing, such as the WRIT program at PNL, the waste-rock interaction programs at Pennsylvania State University, Basalt Waste Isolation Project (BWIP), and the canister-in-salt program at Sandia Laboratories. A major thrust of the systems tests will be to develop the methods and data to determine if the waste management system meets the requirements described by the NRC in the draft 10 CFR 60. These requirements emphasize the canister and/or overpack for an initial time period; later a limiting release from the waste package is specified. Ultimately, systems tests of types 4 and 5 (Table 6.1), will be most pertinent for providing the required data.

Large-scale fully radioactive canisters of waste glass have been prepared in the Waste Solidification Engineering Prototypes (WSEP) program and Nuclear Waste Vitrification Projects (NWVP). The radioactive spectrum was not fully representative in the WSEP canisters, which were heavily weighted with ^{144}Ce and deficient in other fission products and transuranics. The radioactive spectrum was fully representative in the NWVP canisters, however, since the waste came from irradiated LWR fuel. The WSEP canisters have been stored for 10-15 yr. Material data from these canisters will be reviewed.

Systems testing activities will be undertaken by the MCC only after value of the data has been reviewed. In FY 1980, the MCC will evaluate the possible uses of the waste glass canisters prepared in the NWVP. One of these canisters may be placed in the basalt near-surface storage area on the Hanford project in early 1982 for a 3-yr period (an in-situ, 3-yr, systems test). A decision will be reached in mid-FY 1980 on the use of MCC-developed methods to measure pertinent properties of the NWVP canister before and after the in-situ test.

TESTING AREA	TEST DESCRIPTION	SCHEDULE				
		FY 1980	FY 1981	FY 1982	FY 1983	FY 1984
BENCH-SCALE TESTS, RADIOACTIVE	SUBMIT STANDARD TEST FOR WASTE FORM-ROCK INTERACTION TO MRB		▽			
	SUBMIT FIRST WASTE GLASS-ROCK INTERACTION DATA TO MRB			▽		
LARGE-SCALE TESTS, NONRADIOACTIVE	COMPLETE REVIEW OF AVAILABLE DROP TEST DATA		▽			
	DECIDE ON NEED FOR MORE DROP TESTS		▽			
	DECIDE ON NEED FOR FIRE TESTS		▽			
	DECIDE ON NEED FOR SHIPPING ACCIDENT SIMULATIONS AT SANDIA		▽			
	SUBMIT DATA TO MRB ON LEACHING OF FAILED GLASS CANISTER IN WATER BASIN			▽		
	SUBMIT DATA TO MRB ON LEACHING OF FAILED ALTERNATIVE WASTE FORM CANISTER IN WATER BASIN				▽	
LARGE-SCALE TESTS, RADIOACTIVE	PROVIDE INPUT TO TEST PLAN FOR NWVP STORAGE CANISTER	▽				
	DECIDE ON NEED FOR LARGE SCALE TEST-TO-FAILURE RADIOACTIVE TESTS IN SIMULATED REPOSITORY ENVIRONMENT			▽		

FIGURE 6.1. Suggested Schedule for Svstems Tests

6.1.1 Plans for FY 1981

Early in FY 1981, a standard waste form/rock interaction test will be submitted to the MRB. The test will be developed in conjunction with WRIT, Pennsylvania State University, BWIP, and others. Special care will be taken that the test conditions can be documented as being realistic and truly representative of those required to give mathematical modelers meaningful data. It is anticipated that later in the year the first data from the MCC standard tests for canister corrosion in repository environments and waste form/rock interactions will be submitted to the MRB.

Most processed waste forms are ceramics and thus are subject to brittle fractures. The canister contains fracture particles formed during accidental impacts. Consequently, the most meaningful impact tests will be those done on the canister and waste form system. The results of such tests already completed will be reviewed by the MCC in FY 1981. A decision will be made on whether more such tests are required and whether a standard test should be defined.

Analyses of property measurement requirements on the waste form/canister system will continue. Decisions will be reached on the need for tests of the system behavior in a standard fire and on the need for full-scale shipping accident simulations, or the simulation of other severe impact situations such as an airplane crash into an interim surface storage facility.

6.1.3 Plans for Beyond FY 1981

In FY 1982, the first data on the leaching of a failed glass canister in a water basin environment will be submitted to the MRB. By late in FY 1982, it is anticipated that several type 4 and 5 (Table 6.1) laboratory-scale systems tests will have been completed with one or more representative waste glass compositions. Data from tests using different geologic rocks and canister materials will have been submitted to MRB. The emphasis will change to alternative waste forms and, by the end of FY 1983, systems test data on several alternative waste forms will have been submitted to the MRB. Full-scale canisters of alternative waste forms will be fabricated with a leak simulating a stress-corrosion crack, and the leaching behavior in a water basin environment will be tested.

A major decision will be required in FY 1982 concerning the necessity of scaling-up the type 4 and 5 systems tests (Table 6.1). These are the ultimate demonstration tests. Sufficient data on bench-scale tests of this type will be available to assess whether data from these miniature simulations of what in reality is a much larger system will suffice to yield adequate data for the mathematical models, or whether the system must be tested on a more realistic scale with full levels of radioactivity in the waste forms.

7.0 DATA DISSEMINATION

A major objective of the MCC is to document materials data in a Nuclear Waste Materials Handbook. In addition to data, the handbook will describe the test methods used to obtain the data. It will be organized to facilitate comparison and evaluation of alternative materials and to be used by design engineers. Other important methods of disseminating information from the MCC will include data compilation reports, workshops and information meetings, newsletters and open-literature publications.

7.1 DATA COMPILATION REPORTS

Many tests have been devised and used to measure properties of waste forms and other materials of interest in the disposal of radioactive wastes in repositories. The data from these tests are widely reported in the literature. Sources include all DOE laboratories and operating contractors, univeristy contractors, private organizations, and foreign organizations. Literature searches in support of the development of certified test procedures will be used to identify, summarize, and screen data. This information will then be compiled for reference in a series of reports.

These compilation reports will summarize the state-of-the-art relating to the properties of waste materials. The reports will encompass the range of variables relative to the suitability of a material for placement in geologic repositories. Thus, the data will include information on the effects of temperature, radiation, potential hydrological conditions, and potential geologic interactions. These reports will not require MRB review or approval.

7.1.1 Waste Form Materials

A compilation of waste form materials properties will be the first major report of the MCC. The initial compilation of data will concentrate on waste forms currently being developed. The first issue of the compilation report on waste forms will be published in FY 1980 to provide maximum guidance in the development of key test procedures and the collection of test data for the first inputs to the Materials Handbook.

7.1.2 Engineered Barrier Materials

A compilation report on the materials characterization of engineered barriers (canister, overpacks, and backfill materials) will be developed based on studies discussed in Section 6. This report should be available in the first quarter of FY 1981.

7.1.3 Systems

The MCC will report results of testing and data relating to interaction of waste forms, barriers, and other materials in a repository. The MCC will work with organizations performing system studies to assist in definition of test requirements and interpretation, with the intent of early approval of integrated test methods. All such tests and test results may be summarized in a compilation report.

7.2 NUCLEAR WASTE MATERIALS HANDBOOK

The Nuclear Waste Materials Handbook will be the authoritative reference for all waste package materials going into geologic repositories. It will include only those test methods and data approved by the MRB. Emphasis will be on those data related to chemical, physical, mechanical, and radiation stability, interactions with other materials, chemical and microstructural analyses, and other properties that relate to long-term safety. Routine screening data from product and process development will not normally be included.

Format details of the Materials Handbook will be established only after consultation with potential users, but it will probably be divided into three main parts. One part will contain the test methods that have been approved by the MRB. These methods will be used to obtain certified data on nuclear waste materials. In the second part, waste materials that have been tested will be listed individually. This will be the comprehensive collection of data. The materials will be described in detail, and all of the properties that have been measured on the individual material will be given, with emphasis on the range of experimental parameters over which the measurements have been made. For materials that have been investigated very thoroughly, many pages may be required; for other materials, investigated less intensively, only one to two pages may suffice. The third part will serve as a convenient cross index. The data will be summarized with references to the pertinent sections of the previously described parts for details. The main purpose of the third part will be to facilitate comparisons between waste materials.

The Materials Handbook will be formed using a loose-leaf binder similar to the DOE Nuclear Systems Materials Handbook.[a] Thus, the handbook can be readily updated by additions, revisions and deletions. Pagination control sheets will provide current records of the validated data sheets and measurement methods.

A detailed outline of the Materials Handbook will be available in June 1980. The first approved test methods with supporting data will be published in handbook format in September 1980.

7.3 WORKSHOPS AND INFORMATION MEETINGS

Workshops will be held at appropriate times during the developing of test methods to obtain the broadest possible consensus that a particular approach to testing gives suitable and interpretable data. Workshop participants will be experts from universities, industry, DOE laboratories, and government agencies. The first workshop, on waste form leaching, was held in February 1980. Others, on overall data needs, canister materials, thermal effects, and radiation effects, will be held as soon as practicable. Most workshops will be in 1980 since it is important to factor this input into the MCC work plan as early as possible. Standing committees of experts (consultants), that will meet in a series of follow-on mini-workshops, may be organized on some subjects.

Information meetings will be held periodically to advise the nuclear waste management community of MCC activities. Some of these information meetings may be opened to the public and some may be held in conjunction with workshops.

(a) Nuclear Systems Materials Handbook. Volume 3 Materials and Process: Section and Control. TID 26666, Vol. 3, Hanford Engineering Development Laboratory, Richland, WA.

7.4 NEWSLETTERS

The nuclear waste management community and interested public and technical groups will be kept informed of the work and conclusions of the MCC by published newsletters. One of the main purposes of these communications will be to provide early notice of new methods under development, methods submitted for approval to the MRB, and advance notice of certified data.

7.5 OPEN-LITERATURE PUBLICATIONS

The best and most accepted method of critiquing results and debating technical issues on a broad basis is by publication in a major referenced journal. Accordingly, test methods and data will be published in open-literature publications to solicit comments. Similarly, the activities and results of the program will be presented and discussed frequently at national and international meetings.

APPENDIX A

CHARTER

NUCLEAR WASTE MATERIALS CHARACTERIZATION CENTER

CHARTER

NUCLEAR WASTE MATERIALS CHARACTERIZATION CENTER

This charter defines the mission, authority, functions, interfaces, documentation, and funding of the Nuclear Waste Materials Characterization Center (MCC), which is an integral part of the Nuclear Waste Materials Characterization Organization sponsored by the Office of Nuclear Waste Management within the Department of Energy.

MISSION

The mission of the MCC is to provide the materials data base and supporting documentation to help ensure safe disposal of nuclear waste. This data base will include information on components of the waste emplacement package, which includes either the spent fuel or processed waste form, the engineered barrier, and their interaction with the host environment. These data will be generated either by the MCC or by others using test methods published by the MCC and believed to be representative of the conditions expected in the waste management system during interim storage, transportation, and disposal. The data will form the basis for waste materials specifications, testing standards, quality control procedures, and licensing action. These data may also be used to compare qualifications of alternative waste forms and of alternative components in the waste emplacement package. Materials data and test procedures will be approved by the Materials Review Board (MRB) and will be compiled, issued, and updated by the MCC as a Nuclear Waste Materials Handbook.

AUTHORITY

The MCC performs its function by authority of the Materials Steering Committee (MSC) of the Office of Nuclear Waste Management (NWM) of the Department of Energy. The MCC reports on its activities and is responsible to the MSC through the contracting field office and the appropriate lead office.

FUNCTIONS

The MCC will plan materials testing, develop and document procedures, collect and analyze existing materials data, and conduct tests as necessary to ensure that validated data on proposed waste materials are available. for evaluating the data, the MCC will develop methodology that will be subject to review and approval by the MRB. In this function, the MCC shall consider the efforts of other standard-setting groups. The MCC will coordinate its functions with DOE, its contractors, and other technical groups to avoid duplication of effort and to ensure completeness of the materials testing program. The MCC, upon request, may perform materials property tests and characterization in accordance with its established procedures.

The MCC will function as a clearinghouse for procedures and data on waste materials pertinent to processing, transportation, interim storage, and disposal. Procedures and data will be accepted from outside MCC for review, testing, and submittal to the MRB. Periodic reviews, coordination meetings, and workshops will be held for MCC functions.

The validated data will characterize waste materials for their radiological, chemical, physical, and metallurgical properties, such as identification of phases and microconstituents, leach rate, corrosion rate, chemical reactivity and stability, volatility, strength, fracture behavior, air dispersibility, phase stability, gas generation potential, water release potential, and reactivity with geologic media. The effect on these properties of such variables as time, temperature, radiation level, stress, and chemical environment will be evaluated. The interactions of the waste emplacement package components with each other and with their environment will also be considered. The environmental conditions of the repositories and materials of interest will be defined by the National Waste Terminal Storage Program. Through these testing activities, the MCC will assist in identifying the needs for approved materials specifications and development of materials.

Relevant testing procedures will be either developed or obtained by the MCC for review by the MRB. Once approved, such procedures will be applied to candidate waste emplacement package materials to ensure a consistent basis for comparison. Particular attention will be devoted to developing accelerated tests that can be used to predict the behavior of materials and systems for long periods in a repository. Testing methods may also be developed for integrated systems that include waste form, canister, overpack materials, and other potential barrier components within various simulated host environments.

INTERFACES

The MCC will be concerned with waste materials and information that are part of the following programs and current DOE lead offices:

- High-Level Waste Program (SR)
- TRU Program (AL)
- Waste Isolation Program
- Transportation Program (AL)
- Low-Level Wastes (ID/OR)
- Airborne Effluents Program (ID)
- International Programs.

The test procedures will be developed by the MCC using acceptance criteria and repository requirements defined by DOE in accord with regulatory performance requirements. The MSC is expected to maintain a base-funded program for the MCC. The MCC will provide limited analytical services pertinent to its mission for each of the above programs on a cost recovery basis. The MCC will involve other qualified organizations, universities, and individuals in preparing procedures, conducting tests, generating data, and consulting. In all cases, the MCC will be responsible for the final data submitted to the MRB for review.

Developed test procedures and supporting data will be submitted for review to the MRB. Approved test procedures will constitute the formal tests to be used by laboratories to qualify materials, define process conditions, and evaluate waste package components. Similarly, the data generated by the MCC, its subcontractors, and other programs will be submitted, with necessary supporting information, by the MCC to the MRB for approval before incorporation into the Nuclear Waste Materials Handbook.

The MCC will make available to the Independent Measurement Standards Laboratory (IMSL), established as part of the Materials Characterization Organization, all data pertinent to test procedures related to the MCC mission. Further, the MCC will be open for having the IMSL review, discuss, and comment on its activities. Reference test procedures and standards produced by the IMSL may be used by the MCC.

The program of the MCC will be subjected to review by the MRB. Specific program direction will be provided to the MCC by the contracting field office in response to decisions and guidance provided by the MSC through the responsible lead office.

DOCUMENTATION

The MCC will publish the Nuclear Waste Materials Handbook, a separate compilation report of unvalidated data, topical progress reports, and open literature publications to document the functions described above. In addition, it will contribute to the periodic management and technical reports of the lead offices supporting their work.

FUNDING

Base funding and program coordination will be provided by the HLW Lead Office (SR), with supplemental funding from other offices depending on their program requirements.

APPENDIX B

THE DOE ORGANIZATION FOR MATERIALS CHARACTERIZATION

THE DOE ORGANIZATION FOR MATERIALS

CHARACTERIZATION

The Department of Energy Office of Nuclear Waste Management has developed an administrative organization to provide an unbiased, referenceable basis for establishing test methods and determining properties of nuclear waste materials. This organization represents the waste processing, transportation, and isolation responsibilities and responds to the Interagency Review Group (IRG) mandate for a systems approach to waste management. The organization has four parts, related as shown in Figure B.1.

- Materials Steering Committee (MSC)
- Materials Characterization Center (MCC)
- Materials Review Board (MRB)
- Independent Measurement Standards Laboratory (IMSL)

Requirements have been imposed for independent reviews and assessments, and charters have been developed that establish the mission and responsibilities of each group. The MCC charter is in Appendix A and the MRB charter is in Appendix C.

The Materials Steering Committee (MSC) is the administrative head of the organization. The committee is composed of the waste program technical division directors, project leaders, and representatives from the following field offices:

- Albuquerque for TRU and transportation programs
- Savannah River for HLW programs
- Richland-Columbus for terminal isolation program

The Chairman of the Materials Steering Committee is the Director of DOE's Division of Waste Isolation. The steering committee is responsible for, and supports, the activities of the operational materials characterization organizations. The Steering Committee responsibilities also include review and approval of the charters and organization of the MCC, MRB, and IMSL, and resolution of any issues that may arise between groups in the conduct of their

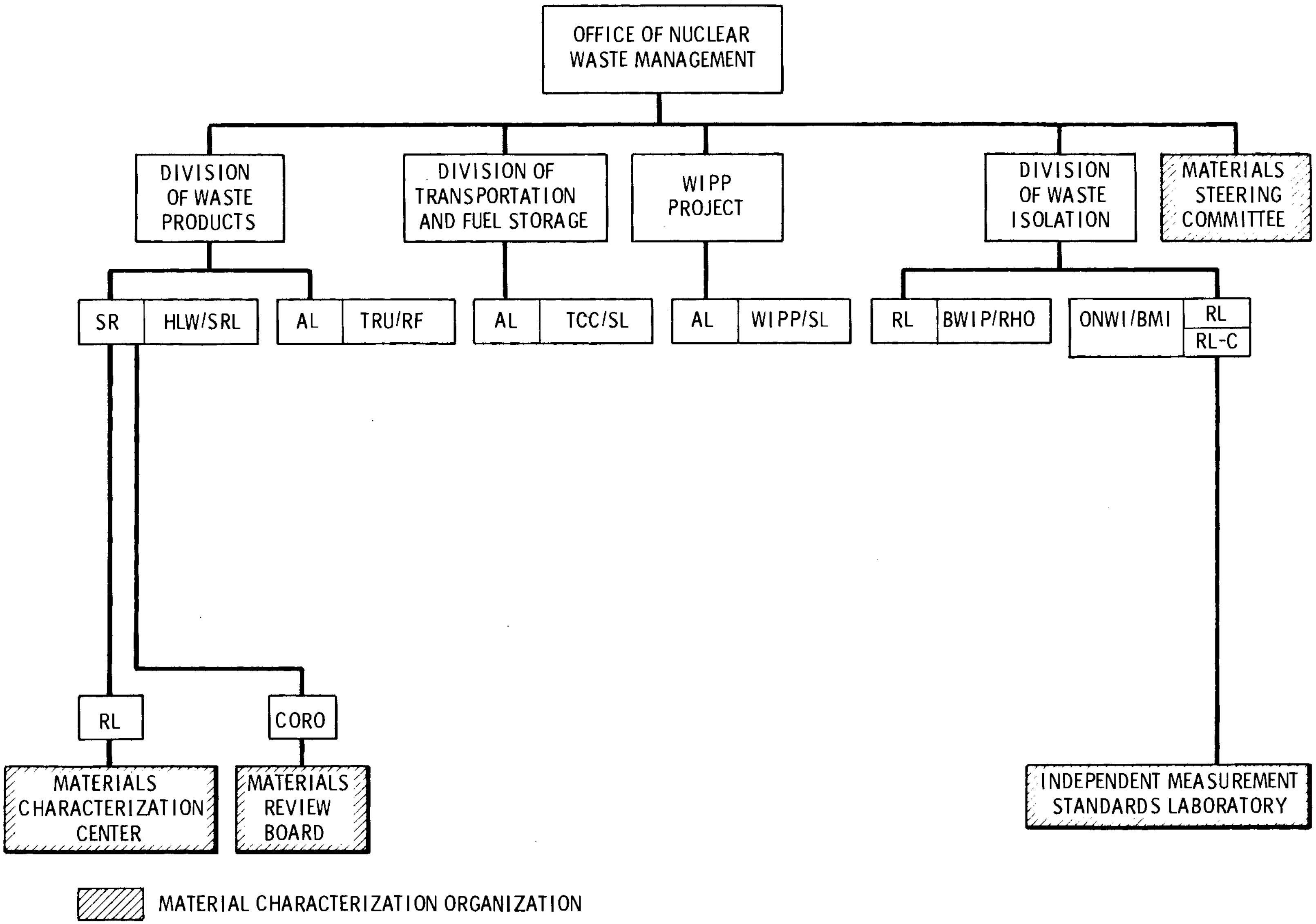

FIGURE B.1. DOE Organization for Waste Materials Characterization programs. The Steering Committee will also ensure that the materials work is effectively interfaced with users of the data: the waste form, package, transport and repository developers and, ultimately, the facility designers and operators.

The MCC has the responsibility for developing test methods and generating data on waste materials. Its functions are described in greater detail thoughout the program plan. The MCC reports to the MSC through the Division of Waste Products, Savannah River Operations HLW Lead Site, and Richland Operations Office.

The MRB's responsibility is to review the test methods and data produced or submitted by the MCC for their technical quality and applicability. The review process will ensure that data and test methods used in the development and execution of nuclear waste management technology is demonstrably reliable. The membership of the MRB consists of technical experts from DOE laboratories universities, or industry. The MRB will utilize the IMSL for resolution of technical difference and for supporting data. The MRB reports to the MSC through the Division of Waste Products, Savannah River Operations HLW Lead Site and the Chicago Operations Office.

The IMSL has the responsibility to provide standard materials, provide technical reviews, and can develop selected test methods and data. It reports to the steering committee through the Division of Waste Isolation, Richland Operations - Columbus, and the Office of Nuclear Waste Isolation.

APPENDIX C

CHARTER

MATERIALS REVIEW BOARD

CHARTER

MATERIALS REVIEW BOARD

I. MISSION AND SCOPE

The Materials Review Board (MRB) shall provide independent assurance that essential materials data, produced and provided by the Materials Characterization Center (MCC) and used by the Office of Nuclear Waste Management (NEW), has been objectively developed and is technically and scientifically valid. The MRB is charged with the responsibility of approving the waste materials data destined for the Waste Materials Handbook and of the test procedures pertinent to establishing these data. The MRB shall include in the scope of its activities the review of scientific and technical bases of data and test procedures, and review of the relevance of these data and procedures to the disposal and assurances criteria. Pertinent committees and subcommittees of the MRB may perform review functions in concert with specific parts of the Board's mission; final action, in all cases, is reserved for the entire Board.

The MRB is also required to review the programs of the MCC and provide periodic assessments of these programs to the Materials Steering Committee (MSC) through the appropriate lead office.

II. AUTHORITY

The MRB performs its function by authority of the MSC of the Office of Nuclear Waste Disposal (NEW) of the Department of Energy. The MRB, through its chairman, reports on its activities and is responsible to the MSC through the appropriate lead office.

III. ORGANIZATION

The MRB is composed of representatives of various organizations, including national laboratories, the MCC, the Independent Measurements Standards Laboratory (IMSL), DOE contractors, industrial firms, and universities. The specific composition of the MRB is determined by the MSC and membership on the MRB requires the approval of the MSC. The MRB includes the Office of the Chairman, who will serve as the Chief Executive Officer of the Board and its committees. In order to carry out its function in an expeditious manner, the MRB will include at least two committees drawn from its membership: a Committee on Test Procedures, and a Committee on Data Release. Each committee will consist of no more than eight board members and will be chaired by the Board Chairman or an appropriate designate. Membership in committees and their subcommittees will be assigned by the Chairman.

IV. INTERFACES

All communications by and on behalf of the MRB will be the responsibility of the Chairman of the Board. Communication with other groups, as herein described, may be through the appropriate DOE field office at the discretion of the MRB.

The MRB will provide information concerning its activities to the MSC and to the appropriate lead offices. The appropriate lead offices will maintain an active exchange of information with the Board, designed to assure that the Board's functions are in accord with the policies governing the DOE program. The MRB chairman shall be available to the MSC for consultation as needed.

The MRB and its committees will issue direct requests to, and receive information from, the MCC pertinent to the Board's functions of review and approval of data and test procedures, and of review of the MCC program. Results of approval and review actions of the MRB pertinent to waste materials will be communicated to the MCC, and via the appropriate lead offices to the MSC.

The MRB may request the assistance of the IMSL in order to resolve technical issues that have arisen in connection with the functions of the MRB. Such requests will be addressed directly to the IMSL.

The MRB will communicate with other organizations having responsibilities in waste management assigned by ETW, including those groups with responsibilities related to the repositories. The Board may directly request from groups, such as the Office of Nuclear Waste Isolation (ONWI), data or information that are believed to be necessary for the timely completion of the functions of the MRB.

The MRB shall not be constrained in its contacts with groups or individuals related to the assigned functions of the MRB, except that all official contacts with other than DOE-related groups shall be subject to prior approval by the appropriate lead offices. The MRB shall communicate directly with the Director of ETW if, in its judgment, matters of sufficient importance warrant such action.

V. OPERATIONS

The Chairman is responsible for calling meetings, development of agenda, and submission of procedures and data to the MRB for review or approval. The MRB shall meet periodically to enact such matters as have been placed on the agendum. The Chairman shall develop such functional procedures as are necessary for the efficient conduct of business by the Board and committees. The Office of the Chairman may include supporting staff to whom assignments may be delegated.

Approval of data and test procedures by the full Board must be preceded by action of the appropriate committee. Such action shall include review of material submitted by the MCC, assembly of supplemental data as required, solicitation of independent opinions as may be needed on technical issues, and formal action by the committee indicating the opinion of its members on the matter under study. The committee's final actions are required before the matter is brought before the full Board for formal action. Full Board action may be acceptance or approval, rejection or denial of approval, or return of the matter to the committee for further study. The committee of the full Board may elect to request the MCC to reevaluate or amplify the data or procedures provided to the MRB.

In the case of action by the full board, or its committees and subcommittees, opinions differing from the prevailing view shall be recorded when those dissenting members provide to the chairman a written document clearly stating the reasons for their opinion.

It is expected that the committees will consist of Board members and such consultants to the committee members that may be required to aid them in their assignments. Further, either committee may form subcommittees that deal with specific assignments. The membership of each subcommittee will be drawn from the membership of Board members serving on the corresponding committee, but different consultants may be used by each subcommittee depending on the skills required to complete the particular assignment.

The MRB may request that the IMSL provide expert opinions on technical issues, supplemental to data already available of adjudicatory to conflicting data. In the latter case, the MRB shall accept the conclusions of or data from the IMSL as the prevailing information.

VI. DOCUMENTATION

The MRB shall cause such records of its activities to be kept as are needed to reasonably demonstrate the quality of its actions in the discharge of the Board's responsibility. Accessibility to MRB records shall be governed by such guidance as the appropriate lead office may provide. Any minority report filed to validate an opinion dissenting from the majority view will be included in the official records. The condition of approval or release for publication by the MRB of data or procedures shall be noted on all appropriate documents transmitted to the MCC, and may be used by the MCC in official documents.

VII. FUNDING

Funds for the support of the activities of the MRB, including the Office of the Chairman, shall be provided by ETW via the appropriate lead office in response to requests from the Chairman. The Office of the Chairman may issue contracts and make such arrangements with Board members and consultants as may be required and requested by the MRB. Board members from DOE contractors, and others holding current contracts or work authorizations for activities supported by ETW, shall be provided necessary support for membership functions from existing funds; except that funds for the Office of the Chairman shall be provided on a separate basis and be part of the financial plan of the appropriate field office. Financial support of consulting experts, drawn from the organizations represented by board members, will be from ongoing ETW-related programs. Other consultants will be bound by contractual agreements through the Office of the Chairman. In all instances, contracts for services shall be let in accord with applicable DOE rules and regulations governing such activities.

Fiscal support and actions of the MRB and of its members and consultants shall not be a prejudicial factor in authorizing contracts, funding programs or assigning responsibilities to MRB members or their associated institutions by any department or group within DOE.

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